Abstract: The purpose of this study is to describe leveling of students’ creativity in solving geometry problems based on their academic achievements. The indicator of creativity used are fluency, flexibility and novelty meanwhile there are five stages of creativity in mathematics problem solving as proposed by Siswono (2011). It is a descriptive research using qualitative approach. The subject of the research is three students in the first semester of Mathematics Department of University of Muhammadiyah Gresik. We categorized the students based on their mathematics achievement at the first competences, after that we took a student from each level based on their willingness and their ability in communication. Data collections used were documentation, observation and written test. From the data analysis we conclude that Subject S1 (High Achiever) lied in two different levels of creativity. On geometry problems in daily life, her creativity level is at the 3rd levels (creative) and in the problems of geometry theorem her creativity level is 2nd (Quiet creative).Subject S2 (Average Achiever) lied in the same level of creativity. On geometry problems in daily life, her creativity level is in the 2nd level (quiet creative) and in the problems of geometry theorem her creativity level is 2nd (Quiet creative).Subject S3 (Low Achiever) lied in two different levels of creativity. On geometry problems in daily life, her creativity level is at the 1st levels (less creative) and in the problems of geometry theorem; her creativity level is 0 (Not creative).

Key Words: Mathematics Creativity, Level, Geometry

1. INTRODUCTION

The Implementation of Indonesian Presidential Decree No. 8, 2012 about KKNI-Kerangka Kualifikasi Nasional Indonesia (Indonesian National Qualifications Network) changes the higher education curriculum paradigm from competence achievement to learning outcomes achievement. Learning outcomes is identified as skills which are reached through the internalization of knowledge, attitude, skills, competence and working experiences. In order to reach the outcomes it is very important for the teacher to shift his/her role to facilitate their students to learn. It is also important for the teacher to help students integrate their knowledge and apply what they learned in many situations. Some students may use a lot of time and effort in every chapter of subject matter but they lack of skills in solving various problems especially related to problem situations. Several studies recognized that creative abilities is essential in solving complex individual, social, and global problems (Amabile, 1983, 1985, 1989; Brown, 1981; Guilford, 1981; Plucker, Beghetto, & Dow, 2004; Wang, 2011).

Creativity is an interest topic to discuss but it is quiet complex and thus creativity has been defined in many ways by different authors (Gomes: 2007). Cambridge Dictionary mentioned that creativity is the ability to produce original and unusual ideas. Bergström at Pehnoken (1997) described creativity as “performance where the individual is producing something new and unpredictable”. According to Munandar(2009) creativity means a capability to see or to think in an extra ordinary way or uncommon, fuse unrelated information and give new solutions or new ideas which shows fluency, flexibility and novelty in thinking. The definitions imply that creativity is happened when someone produces something that new, original or in an extraordinary way which shows fluency, and novelty in thinking.

Creativity is not a characteristic in certain subjects such artists and scientist but it is a part of daily life, Pehnoken (1997). Mann (2006) also stated “the essence of mathematics is thinking creatively”. Bishop (1981) pointed two different complementary modes of thinking in mathematics namely creative thinking and analytical thinking. Creative thinking is an “intuition’ typical and analytic is “logic”. While a
mathematician encounters a new problem we can see the creative performance. First he would experiment at random then they may set hypothesis which they try to prove gradually.

Bergström 1984 (cited in Pehkonen: 1997) introduced the concept of “everyday creativity” and “Sunday creativity” but was not specific to creativity in mathematics. The development of mathematical thinking in problem solving described by Gotoh (2004) on three stages, (1) the empirical/informal activity, (2) the algorithmic/formal activity, and (3) the constructive/creative activity. In similar Erycnck (cited in Aizikovitsh, 2014) mentioned three stages of mathematical creativity which are preliminary stages, algorithmic activity and creative activity. In Preliminary stage students can apply the mathematical rules and procedure without knowledge of the theoretical foundation. Algorithmic stages emphasize the ability of students to use the rules or procedures with the knowledge of theoretical foundation. In this stage students may involve modeling a situation and may include solving a word problem. Meanwhile in creative stage students involve non-algorithm where entail his/her new understanding of definitions or a new theorem. Aizikovitsh, (2014) stated that in this stage students employ sophisticated methods usually based on his/her assumption embedded in the problem.

To develop mathematics creativity in learning process teacher should pay attention to teaching materials and students’ role. We used CORE (Connecting, Organizing, Reflecting and Extending) model to facilitate various interaction, small group discussion, and students’ presentations, and to provide opportunities to struggle with open ended and or uncommon problems. CORE model consist of four stages namely Connecting, Organizing, Reflecting and Extending. In connecting stage, students connect their initial and new knowledge or between concepts. Organizing means organize the ideas to understand subject matters. Reflecting means rethinking, thinking in depth what they learned and Extending means an activity to develop, extend, use and create something different or new. We assumed that such situations could foster students to experience creativity in mathematics and thinking as mathematician in which they would try to encourage reflecting their ideas. The strengths of this model are students more active, they train to think critically toward a concept or a problem and the learning process give more experience to students. Meanwhile sometimes to implement the model teacher need an extra time and it may suitable for certain matter.

CORE model was implementing with problem solving during the Organizing stage. During the implementation of CORE model, we provided module and students’ worksheet for every meeting. We also gave many references for the students so that they could prepare themselves before the lesson. Problem solving according to Silver (1997) can be used to develop mathematical creativity. He stated that the indicators of students’ creative thinking are fluency, flexibility and novelty. Fluency in problem solving means students ability to obtain many solutions to a problem. Flexibility defined as students’ ability to solve a problem using many different methods meanwhile novelty includes an original solution which is uncommon for that student; grades or knowledge level. (Siswono, 2011) stated that there are similar characteristics among the level of creativity in problem posing and problem solving. He mentioned the levels of creative thinking in problem solving as follows:

<table>
<thead>
<tr>
<th>Creativity Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Very Creative</td>
<td>Student is able to solve a problem with more than one solution and can represent another way to solve it. One solution fulfills originality (novelty).</td>
</tr>
<tr>
<td>Level 3 Creative</td>
<td>Student is able to solve a problem with more than one solution, but he/she cannot represent another way to solve it. One solution fulfills originality (novelty). An alternative characteristic, he/she can represent another way to solve a problem, but he/she cannot make a novelty solution.</td>
</tr>
<tr>
<td>Level 2 Quite Creative</td>
<td>Student is able to solve a problem with one original solution however it does not fulfill fluency or not flexibility. Or, he/she can represent another way to solve a problem; however, it is not novel for not fluency.</td>
</tr>
</tbody>
</table>
Based on the characteristics of the problems and the indicators of creativity, we made the indicators of creativity level as follow:

<table>
<thead>
<tr>
<th>Creativity Level</th>
<th>Fluency</th>
<th>Flexibility</th>
<th>Novelty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Very Creative</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Level 3 Very Creative</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Level 2 Quite Creative</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Level 1 Almost Not Creative</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Level 0 Not Creative</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note:
Flexibility at level 3 means students find more than a solution for the problems, meanwhile for the level 2 flexibility means students only get one way to find the solution.

2. RESEARCH METHODOLOGY

It is a descriptive study with qualitative approach because the purpose of this study is to describe the level of students’ creative thinking in solving geometry problems based on their academic achievements. The subject of this research is students in the first semester of mathematics education department in University of Muhammadiyah Gresik in 2015-2016 academic year. In order to get the data we used documentation, written test and interviews. We used triangulation time to get the validity of the test in which the researcher gave the test and did the interview that equivalent with the problems on the test at different time.

We ranked the students according to their achievement in the first test of Plane Geometry subject before the research. After that we categorized their score based on Arikunto (2003) as follows:
Table 2. Academic Achievements’ Category

<table>
<thead>
<tr>
<th>SCORE</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>$x \leq 68,06$</td>
<td>Low</td>
</tr>
<tr>
<td>$68,06 &lt; x &lt; 78,69$</td>
<td>Average</td>
</tr>
<tr>
<td>$x \geq 78,6$</td>
<td>High</td>
</tr>
</tbody>
</table>

After that we took a student in each category based on (1) their own willingness in participating the study (2) their ability in communicating their ideas written or orally. The students are FPS/S1 (high category), DA/S2 (average category) and DAL/S3 (low category). We analyzed these three students’ answers and after that we interviewed them at different time to confirm their answer and get further explanation. Based on the students’ test and interview we describe the creativity of the students based on their academic achievements.

We saw the level of students’ creativity by giving them two problems in geometry. The first problem is the application of geometry in daily life and the second problem concern with geometry theorems. The application problem as follow:

*A monument was built in the center of three streets and making a triangle, the distance between the monument and those three streets around is equal. The length of each street 10 m. Determine:*

a) *The distance of each street to the monument,*
b) *The area of kite made by the monument and the street*

Meanwhile the problems related to the geometry theorem concerned with parallelogram is:

*Given a parallelogram KLMN with ME as theheight. Prove that the area of it is KN.ME*

3. FINDING AND DISCUSSION

This research was part of Implementation of Lesson Study. Four lecturers work collaboratively in planning the lesson, conducting the lesson and reflect the learning process. We categorized 16 students on the first semester based on their achievement on the first test. There are 3 high achiever, 10 students are average and 3 students are low achiever. We selected a student from each category. The level of mathematics achievement for subject 1 (S1) is high, for the subject 2 (S2) is middle, and subject 3 (S3) is low. From the test we got that students mark respectively from the high to low as follow 90, 70 and 40. Having determined the subject of the study, then we analyzed the video observation especially during the presentation and observed the test in the last period. We saw the level of students’ creativity with two problems given in geometry course. The first problem is the application of geometry in daily life and the second problem concern with geometry theorem.

From the observation during the implementation of CORE method we found the level of students’ creativity as follow:

a. **High Achiever Student’s(S1)creativity in solving daily life problems in Geometry**

Creativity level of subject 1 (S1) on Application problem lied in level 3(creative) since subject S1 satisfy two aspects: fluency and flexibility. S1 was able to solve the given problem correctly, and found the solutionthrough isosceles triangle and an inner circle of the triangle. S1 provided every step clearly and the pattern given is different from the reference given. S1 explained on the interview that she found that the kites are congruent so that she could divided the area of the triangle by three to get the area of a kite. Another way is findingthe area of the circle in the triangle then subtracts the area of the triangle by the area of a circle and divided it into three equal parts. One part of the area adding with the area of a sector is the area of a kite.
The novelty didn’t appear on her solution so that on the interview.

b. **High Achiever Student’s creativity related to geometry theorem**

From the analysis conducted, creativity level of subject 1 (S1) lies in the level 2 (quite creative) since subject S1 satisfy two aspects: fluency and flexibility. Subject S1 is able to answer the question correctly, provide the steps but the pattern same with the references given.

To prove the theorem, S1 used a parallel line with ME through point D so that she got a rectangle. The base of a parallelogram is same with the length of the rectangle so that the height of the parallelogram. She found two congruent triangles so that the area is same. Finally she showed that the area is KN. ME as mentioned in the problem so that the theorem was proved. Here is S1 answer on the first problem.

![Picture1](S1’s Answer on application problem)

The fluency and flexibility in providing answers might also affected by other references. So the novelty aspect has not yet appeared.

c. **Average Achiever Student’s creativity in solving daily life problems in Geometry**

From the analysis conducted, creativity level of subject 2 (S2) lies in the level 2 (Quite Creative), where in solving daily life problem in geometry, the subject S2 made a picture to solve the problem. S2 satisfy two aspects: fluency and flexibility. First S2 calculated the distance of each street to the monument using the formula, \( r = \frac{l}{2} \), after that found the area of the circle in the triangle then subtracts the area of the triangle by the area of a circle and divided it into three equal parts. One part of the area adding with the area of a sector is the area of a kite.

From the interview, S2 said that she look for and read other references before the lesson took place. It is may imply S2 answer toward the problem.

d. **Average Achiever Student’s creativity related to geometry theorem**

From the analysis conducted, subject 2’s (S2) creativity level in proofing geometry theorem lies in the level 2 since S2 satisfy two aspects: fluency and flexibility but not with different solution patterns. Subject S2 is able to provide the steps correctly but the pattern is equal to the reference given or taken. S2 using the same approach with S1 but she gave more note on the picture and explained step by step explicitly, but less practice compare with S1.

The fluency and flexibility in providing answers is also affected her willingness to look for and read other references. The novelty aspect has not yet appeared.

e. **Average Achiever Student’s creativity in solving daily life problems in Geometry**

From the analysis we can say that the creativity level of subject 3 (S3) in solving daily life problem lies in level 1 (almost not creative), subject S3 is only fulfill 1 aspects. That is fluency. In working on the problems, Subject S3 are able to provide the steps to solve the problems but the
pattern she used was equal to the reference given. S3 cannot provide different solution due to the lack of reference that she brought. S3 only use references given by lecturers. From student’s work, flexibility and novelty aspect has not appeared because the subject was not able to explore concepts beyond existing references. From the presentation video during the Lesson, subject S3 is unable to answer/explore other solution given to other groups.

f. Low Achiever Student’s creativity related to geometry theorem

From the results of the analysis, creativity level of subject 3 (S3) lies at level 0, while solving problem related to geometry theorem, S3 was not meet the 3 aspects. Subject S3 is only able to copy the concept given and cannot complete the answer. S3 was not carrying other references. In the presentation video during the Lesson, subject S3 are not able to explain well and she was not give many argued.

The table below is a summary of the results of the analysis of students’ level of creativity in geometry problems related to daily life situation and theorem.

<table>
<thead>
<tr>
<th>No</th>
<th>Subject</th>
<th>Indicator of creative</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fluency</td>
<td>Flexibility</td>
</tr>
<tr>
<td>1</td>
<td>S1</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>2</td>
<td>S2</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3</td>
<td>S3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 4. Level of students’ creativity in solving theorem problems in Geometry

<table>
<thead>
<tr>
<th>No</th>
<th>Subject</th>
<th>Indicator of creative</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fluency</td>
<td>Flexibility</td>
</tr>
<tr>
<td>1</td>
<td>S1</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>2</td>
<td>S2</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>3</td>
<td>S3</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Form the analysis of the data we know that no one of the subject at the top category of creativity. The highest level that they got is 3rd level which is in the very creative category on the application problem. On the theorem problem, the highest is 2nd level (quite creative). From the data we know that daily life problem give more probability to show students’ creativity than theorem problem. When proofing the theorem, students must aware with certain axioms, or other theorems so that it is not easy to find another solutions since not all the axioms or theorems appropriate with the theorems that they want to proof.

The Subjects of this study are students in the first semester that accustomed to learn what they get from the lecture as they did in the high school. Reading references before the lesson are very seldom to do. Although reading is not automatically improving students’ creativity, it can provoke students to think out of the box.

Developing Students’ creativity is a longitudinal process. It needs creativity of the lecturer to provide various problems and various model of the lesson so that students’ are treated to be creative problem solvers especially in mathematics.

4. CONCLUSION

Based on the result we can conclude that:

1. Subject S1 (High Achiever) lied in two different levels of creativity. On geometry problems in daily life, her creativity level is at the 3rd levels (creative) and in the problems of geometry theorem her creativity level is 2nd (Quiet creative).
2. Subject S2 (Average Achiever) lied in the same level of creativity. On geometry problems in daily life, her creativity level is in the 2nd level (quiet creative) and in the problems of geometry theorem her creativity level is 2nd (quiet creative).

3. Subject S3 (Low Achiever) lied in two different levels of creativity. On geometry problems in daily life, her creativity level is at the 1st levels (less creative) and in the problems of geometry theorem; her creativity level is 0 (not creative).

5. REFERENCES

Aizikovitsh, Einav. (2014). The Extent of Mathematical Creativity and Aesthetics in Solving Problems among students Attending the Mathematical talented Youth Program.


